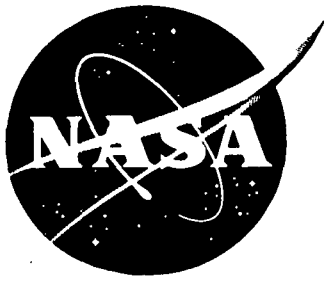
MSC-07603

NASA TECHNICAL MEMORANDUM

NASA TM X-58101
November 1972



STRATIGRAPHY OF THE APOLLO 15 DRILL CORE

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS 77058

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM X-58101		

4. Title and Subtitle	5. Report Date
STRATIGRAPHY OF THE APOLLO 15 DRILL CORE	November 1972
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Grant Heiken, Michael Duke, Roald Fryxell, J. Stewart Nagle, Ron Scott, and G. A. Sellers	MSC-07603
	10. Work Unit No.
9. Performing Organization Name and Address	914-40-52-00-72
Manned Spacecraft Center Houston, Texas 77058	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Technical Memorandum
National Aeronautics and Space Administration Washington, D.C. 20546	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The crew of Apollo 15 collected a 242-centimeter-long core of the regolith of the moon developed on the surface of Palus Putredinis (3° 39'20"E, 26° 26'00"N). The 2.04-centimeter-diameter core, which has a mass of 1333.2 grams, consists of 42 major textural units, with thicknesses ranging from a few milliliters to 13 centimeters thick. The regolith is not homogeneous and is composed of many layers that are mostly ejecta from impact events.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
• Stratigraphy • Core Sampling • Apollo 15 Flight • Lunar Geology • Regolith • Lunar Soil • Moon	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
None	None	24	

NASA TM X-58101

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By Grant Heiken,* Michael Duke,* Roald Fryxell,† J. Stewart Nagle,‡ Ron Scott,§ and G. A. Sellers‖

INTRODUCTION

The Hadley Rille-Apennine Mountains area of the moon (3° 39'20"E, 26° 26'00"N) was explored by the crew of Apollo 15. Among the 78 kilograms of samples that were returned were one 36-centimeter- and two 64-centimeter-long hand-driven cores and one 242-centimeter-long core collected with a rotary-percussion electric drill. The 242-centimeter-long core, which was collected from the regolith developed on Palus Putredinis, is hopefully a representative section of the regolith developed on the mare surface, although its location at station 8, 50 meters from the Apollo lunar surface experiments package (ALSEP) (fig. 1, from ref. 1) central station, may have been on the edge of a ray (ref. 2).

The purpose of this report is to provide a stratigraphic description based on visual observations made during the dissection of the drill core. This description should serve as a basis on which detailed studies may be carried out.

Those responsible for description and dissection of the core sections are as follows: 15001, Fryxell and Heiken; 15002, Duke and Heiken; 15003, Nagle; 15004, Heiken and Scott; 15005, Sellers and Heiken; and 15006, Heiken and Fryxell. All were ably assisted by Maureen Mitchell, Ed Cornetius, or R. White. Henry Cantu operated the X-ray unit, and Paul Gilmore or Al Locke were responsible for the photographs.

EQUIPMENT AND SAMPLING METHOD

A lightweight electric drill is used for boring holes for the heat flow probe as well as for collecting a core; it has a nominal bit speed of 280 rpm and a percussion

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rate of 2270 bpm. The core is collected in a titanium steel tube that breaks into six sections. The core bit has tungsten-carbide tips. Helical flutes on the outside of the tubes carry excess soil to the surface. Inside diameter of the core sections is 2.04 centimeters. In tests that have been conducted at the NASA Manned Spacecraft Center, only the outermost few millimeters of core have been affected drastically by wall friction.

After drilling is completed, the drill is removed, capped and plugged, then placed in a nylon bag for return. Three of the sections on the Apollo 15 core would not separate; these sections were returned as one section and were broken apart in the laboratory. The uncovered three sections that would not separate (15001 to 15003) were plugged on the lunar surface and taped in the lunar module. The exteriors of the linked core sections were exposed to the atmosphere of the lunar module and command module cabins and had water spots on them (probably caused by sea water splashing into the cabin through an open door after splashdown). The remaining sections were protected by the nylon bag, but the exteriors were exposed to the air in the cabin.

SAMPLING PROCEDURES IN THE LABORATORY

During the preliminary examination of the Apollo 15 samples, the cores were X-rayed and small samples were collected from the bottom of each stem. To obtain a stereo pair, the sections were X-rayed twice by means of a medical X-ray unit in the Lunar Receiving Laboratory. The exposure settings were 93 kilovolts, 100 milliamperes, and 1/5 second, with the X-ray head 0.9 meter above the sample.

Study of the X-radiographs provides a crude indication of grain size and composition of the soil, and the location and orientation of coarser rock fragments (except some breccia fragments, which were transparent at these settings). These images aid in the definition of textural units when the cores are dissected. There is some parallax distortion in the X-radiographs that must be taken into consideration when they are analyzed.

For early allocation to principal investigators and medical staff, 3.75 grams of soil were removed from the bottom of each stem. Included were representative samples collected under red light for thermoluminescence investigations. The entire core cutting and dissection was conducted in a nitrogen atmosphere within stainless steel cabinets that were cleaned to NASA cleaning procedure 2 specifications.

The core was mounted in a cradle, then split in half lengthwise with a milling machine. The split core was removed to another cabinet in a transfer container, where it was mounted on a stage and the upper split tube was removed. The core was then photographed (table I) and described.

The samples then were removed in 0.5-centimeter intervals along the length of the tube, to a depth of approximately two-thirds of the tube diameter. These segments were taken apart with small tweezers, needles, and scoops to get a better overall description of each. If a contact between two stratigraphic units was less than 0.5 centimeter away, the sample was collected up to the contact. Because of slumping, the

location of individual samples was generally within ±0.5 centimeter. For thermoluminescence studies, representative samples for each stratigraphic unit were collected under a red dark-room light.

The samples were sealed in stainless steel and aluminum or stainless steel and Teflon containers for storage. Allocations to investigators were made from these samples.

After dissection, the remaining one-third of the core was removed to a laminar-flow clean bench where it was impregnated with n-butyl methacrylate to make peels. The peels were kept as a permanent stratigraphic record and as a source of oriented grains from the cores.

DEPTH RELATIONSHIPS AND DRILLING SPEED

According to reference 3, the rotary percussion action of the drill did not significantly disturb the core stratigraphy in premission simulations or on the moon. It is thought that the depth relationships were very close to one-to-one. The core is 242 centimeters long and has a mass of 1333.2 grams. Bulk densities range from 1.62 to 1.93 gm/cm^3 (ref. 3).

Variable drilling rates during the boring of the hole for the heat flow experiment and during the collection of the core implied that the regolith at this location consists of a layered sequence. The dissection of the core verified that this was the case.

GENERAL DESCRIPTION OF THE CORE

The identification of stratigraphic units was based on changes in combinations of color, texture, structure, and estimated composition of the coarser rock fragments (table II). Only limited identification of coarser particles with the unaided eye were made during the description and dissection. Petrographic studies were not permitted.

The most common particle type was medium- to dark-grey microbreccia, generally subangular to subrounded, with equant to elongate shapes. Less common were white, feldspar-rich basalt and anorthositic fragments. Near the base of the core, there were medium grey, vesicular and nonvesicular basalt fragments. Details of clast types, and so forth, generally were masked by dust coatings. Black or dark-brown glass droplets and angular glass fragments were present in the soils but were more abundant near the top and bottom of the core.

Several layers at -24.5 centimeters and -83.2 to -94.7 centimeters contained green glass spheres and clastic rocks composed of green glass spheres. This unique glass was present in many of the surface soil samples (ref. 4) and was most abundant at station 7, along the Apennine Front.

Textures ranged from silt-size to pebbly, medium-sand-size soils. The silt-size matrix was ubiquitous and present, to varying degrees, in all layers. All of the

soils were poorly sorted to extremely poorly sorted. The grain size determinations were based on subjective visual and tactile impressions of the soils.

Colors varied from very dark grey (10 YR 3/1) to white (10 YR 8/1). The most common soil color was grey, modified only slightly in value and chroma.

Boundaries between units were generally quite distinct; they could be easily outlined during the dissection. With the exception of less than 1 millimeter of soil along the tube walls, there appeared to be no distortion or smearing of the soil or mixing of layers during the drilling process.

Individual layers ranged from a few millimeters to 13 centimeters thick. A total of 42 major textural units were described within the core. Grading (normal and reverse) of several beds implied that they might have been deposited by turbulent flows, possibly a base-surge type of ejecta cloud. It is also possible that the sorting in an individual layer might have been caused by the pelting of the developing soil surface by micrometeoroids.

CONCLUDING REMARKS

The regolith at the location explored by the crew of Apollo 15 is composed of many thin layers, most of which are probably ejecta from near and far impact events exhibiting a complete spectrum of energies. The regolith at this location is not homogeneous, and no systematic variations are exhibited from bottom to top. This conclusion is tentative, based on only a limited study of the core.

Manned Spacecraft Center
National Aeronautics and Space Administration
Houston, Texas, November 21, 1972
914-40-52-00-72

REFERENCES

1. Swann, G. A.; Bailey, N. G.; et al.: Preliminary Geologic Investigation of the Apollo 15 Landing Site. Apollo 15 Preliminary Science Report, sec. 5, NASA-SP-289, 1972, pp. 5-1 to 5-112.

2. Carr, M. H.; and El Baz, F.: U.S. Geological Survey Map I-723, 1971.

3. Carrier, W. David, III; Johnson, Stewart W.; Carrasco, L. H.; and Schmidt, Ralf: Core Sample Depth Relationships: Apollo 14 and 15. Lunar Science III, ed., Carolyn Watkins, 1972, pp. 122-124.

4. Lunar Sample Preliminary Examination Team: The Apollo 15 Lunar Samples: A Preliminary Description. Science, vol. 175, no. 4020, Jan. 28, 1972.

TABLE I.- NASA PHOTOGRAPHIC COVERAGE OF THE APOLLO 15 DRILL STEM

Section	Predissection	During dissection	Postdissection	Peels	Peel impregnation, etc.
15001	S-72-34095 - 34099 C[a]		S-72-35088 - 35095 B[b]	S-72-35728 - 35734 B	S-72-35159 B S-72-35162 C
			S-72-35151 - 35158 C	S-72-35684 - 35688 B; RF's[c] stereo	S-72-35664 C
				S-72-35735 - 35741 C	S-72-35669 C
				S-72-35659 - 35663 C; RF's stereo	
15002	S-72-30757 - 30762 C	S-72-30805 RF S-72-30806 RF S-72-30807 RF	S-72-35079 B S-72-35172 - 35177 B	S-72-35714 - 35720 B	S-72-35160 B S-72-35163 C
			S-72-35179 C S-72-35165 - 35171 C	S-72-35748 - 35754 C	S-72-35666 C S-72-35668 C
15003	S-72-44653 - 44660 B S-72-44661 - 44668 C				
15004	S-72-31814 - 31819 C	S-72-32280 RF B	S-72-35080 - 35087 B	S-72-35721 - 35727 B	S-72-35161 B S-72-35164 C
			S-72-35178 C S-72-35180 - 35186 C	S-72-35742 - 35747 C	S-72-35665 C S-72-35667 C
15005	S-72-16220 - 16229 C			S-72-19281 - 19296 C	S-72-17893 C
15006	S-72-35647 - 35652 C			S-72-38100 - 38108 B	S-72-38099 B S-72-38100 B
				S-72-37945 - 37955 C	S-72-38101 B

[a]The letter "C" designates a color photograph.

[b]The letter "B" designates a black and white photograph.

[c]The letters "RF" indicate a special photograph of a distinctive rock fragment.

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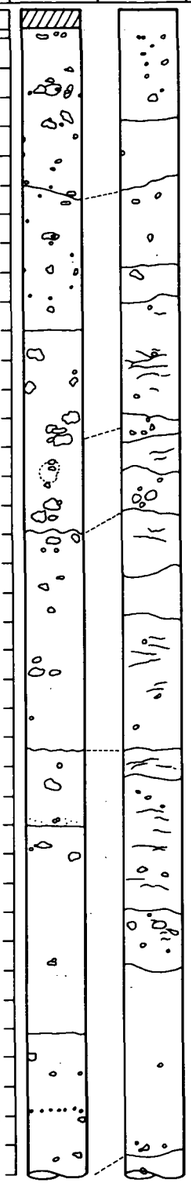
TABLE II. - DESCRIPTION OF THE APOLLO 15 DRILL CORE

Scale; apparent distance below lunar surface, cm	Permanent unit designations	Temporary unit designations	*Scale; from the top of each metal stem, cm	Sketch of core	Sketch of x-radiograph	Photograph of core	Photograph of a peel from the core	Lithologic Description			
								**Color	Texture	Structure	Composition of larger rock fragments	Subunits
0–6	42	006-VI	0–6					10 YR 3/1 (Very dark grey)	Fine sand-bearing silt-size soil. Contains about 1-3% particles greater than 1 mm in diameter. Poorly sorted. Coarser than Unit V.	Subangular to angular blocky structures, 3-4 mm long. Upper 2.5 cm has been somewhat disrupted by the plug. There are some 1-2 mm long cohesive aggregates from 4-5 cm below the top of the core.	1. Black or dark brown glass fragments and spheres, generally less than 1 mm in diameter. 2. Medium to light grey, subrounded to subangular (breccia?) fragments. 3. Subrounded to subangular, white (anorthosite?) fragments.	None
6–11	41	006-V	6–11					10 YR 3/1-4/1 (Dark grey to very dark grey)	Sand-bearing, silt-size soil. Only a trace of particles greater than 1 mm in diameter.	Less coherent than Units VI and IV. Weak, subangular blocky structures, 3-5 mm long.	1. Black to dark brown glass spheres and fragments. 2. Light grey to grey (breccia?) fragments. 3. White (anorthosite?) fragments.	None
11–18	40	006-IV	11–18					10 YR 4/1 (Dark grey)	Sand-bearing silt-size to silt-size soil; poorly sorted. Trace to 3% particles greater than 1 mm in diameter.	Weakly coherent with irregular weak prismatic (3 x 10 mm) structures. Some light grey cohesive aggregate (clods).	1. Dark brown to black glass agglutinates and fragments (some are vesicular). 2. Light to dark grey (breccia?) fragments. 3. White (anorthositic?) rock fragments.	None
18–25	39	006-III	18–25					10 YR 5/1 (Grey)	Silt-size soil; poorly sorted. Trace to 5% particles greater than 1 mm in diameter.	Weak, subangular blocky to prismatic structures (2-7 mm long) strong tendency to form slabs along wall of open core. 3 to 10% of the soil consists of lighter grey, irregular, blocky patches of soil. These "patches" have nearly the same coherence as the surrounding darker grey soil.	1. Light grey to grey breccia fragments (subrounded). 2. Black to dark brown glass fragments and spheres. 3. Fragile, powdery white fragments; possibly anorthosite. 4. Green glass spheres at 24.5 cm below the top of the core.	None
25–28	38	006-II	25–28					10 YR 5/1 (Grey)	Sand-bearing silt-size soil; very poorly sorted. 0 to 5% (near base) particles greater than 1 mm in diameter; may be graded.	Subangular, blocky structures, 1-5 mm long. Weakly coherent.	1. Fine sand size to 2 mm white (anorthositic?) fragments. 2. Light grey (breccia?) fragments. 3. Trace of black glass fragment.	None
28–40	37	006-I	B 28–35 A 35–40					10 YR 4/1-5/1 (Grey to dark grey) for Subunit B 10 YR 5/1 (Grey) for Subunit A	Sand-bearing silt-size soil; 0 to 2% particles greater than 1 mm long. (Very fine grained).	Weakly coherent, subangular, blocky structures (less than 2 mm in diameter) Subunit B is less coherent than Subunit A. Some 1-2 mm diameter cohesive aggregates (clods).	1. Dark brown to black glass fragments and droplets. 2. Light grey, subangular (breccia?) fragments. 3. White (anorthositic?) fragments.	B. Less coherent, darker grey. A. More coherent, lighter grey.

*The individual sample locations are based on this scale.
**Munsell Color Co., Inc., Munsell Soil Color Charts, 1954 ed., Baltimore, Md.

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TABLE II. - DESCRIPTION OF THE APOLLO 15 DRILL CORE - Continued

Scale; apparent distance below lunar surface, cm	Permanent unit designations	Temporary unit designations	*Scale; from the top of each metal stem, cm	Sketch of core	Sketch of x-radiograph	Photograph of core	Photograph of a peel from the core	Lithologic Description				
								**Color	Texture	Structure	Composition of larger rock fragments	Subunits
40			Cont					See previous page for description of unit.				
41	37	006-I-A	40									
42			41									
43			42									
44			3									
45	36	005-VIII	4					10 YR 5/1-6/1 grey	Sandy silt-size soil	Forms coarse friable aggregates. Slumped along edges.	Subunit 4 has a lense of small white and grey soil aggregates. Some grey microbreccia.	None
46			5									
47			6									
48			7									
49	35	005-VII	8					10 YR 4/1-4/2 dark grey to dark greyish brown	Silt-size; very uniform. Some sand-size particles at base; may be graded.	Less cohesive than the units above; few aggregates.	—	None
50			9									
51			10									
52	34	005-VI	11	C				10 YR 5/1 grey	Fine sand size to silt size; containing 5-10% coarse sand to granule-size particles.	Slumps along edge. Soil breaks into loosely coherent aggregates.	Coarser fragments appear to be mostly grey to white microbreccias.	C. Contains white aggregates (See textural description). B. Lens of granule-size rock fragments and abundant white, friable aggregates. A. Similar to Subunit C.
53			12									
54			13	B								
55			14	A								
56			15									
57			16	G								
58			17					10 YR 4/1 (dark grey) near the top; grades down to 10 YR 5/1-5/2 (grey to greyish brown)	Silt-size soil with 2-5% coarse sand or granule size particles.	Consist of coherent aggregates; most are the same color as the matrix, but some are lighter. Probably a coherent layer broken by the drill.	Light grey microbreccias and crystal fragments.	G. Slightly finer grained than the over and underlying units. F. Slightly lighter color than the over and underlying units. E. Abundant white or light grey coherent aggregates 0.5.-1.0 mm long. D. Coarser than B. Contains abundant coherent aggregates which are the same color and texture at the matrix. C. Lens containing about 10% particles > 1 mm. B. Finer grained than C. A. Slightly darker than Subunit B.
59			18	F								
60			19									
61	33	005-V	20	E								
62			21									
63			22	D								
64			23	C								
65			24	B								
66			25	A								
67			26									
68	32	005-IV	27					10 YR 4/1 (dark grey)	15% coarse sand to granule-size particles in silty matrix.	—	—	None
69			28									
70			29									
71			30	C								
72			31									
73			32									
74	31	005-III	33	B				10 YR 5/1 (grey) near the top, grading down to 10 YR 6/1 (grey) near the base.	10-20% particles > 2 mm in a silt-size matrix.	Forms cohesive aggregates (clods). This was probably a very cohesive layer; broken up by the drilling.	Microbreccia fragments in coarse fraction.	C. Contains a Lens of coarse-sand and granule-size particles. B. Large microbreccia fragments. A. Fractured unit; lighter than Subunit B.
75			34									
76			35									
77			36	A								
78			37									
79			38									
80			39									
			40									

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TABLE II. - DESCRIPTION OF THE APOLLO 15 DRILL CORE - Continued

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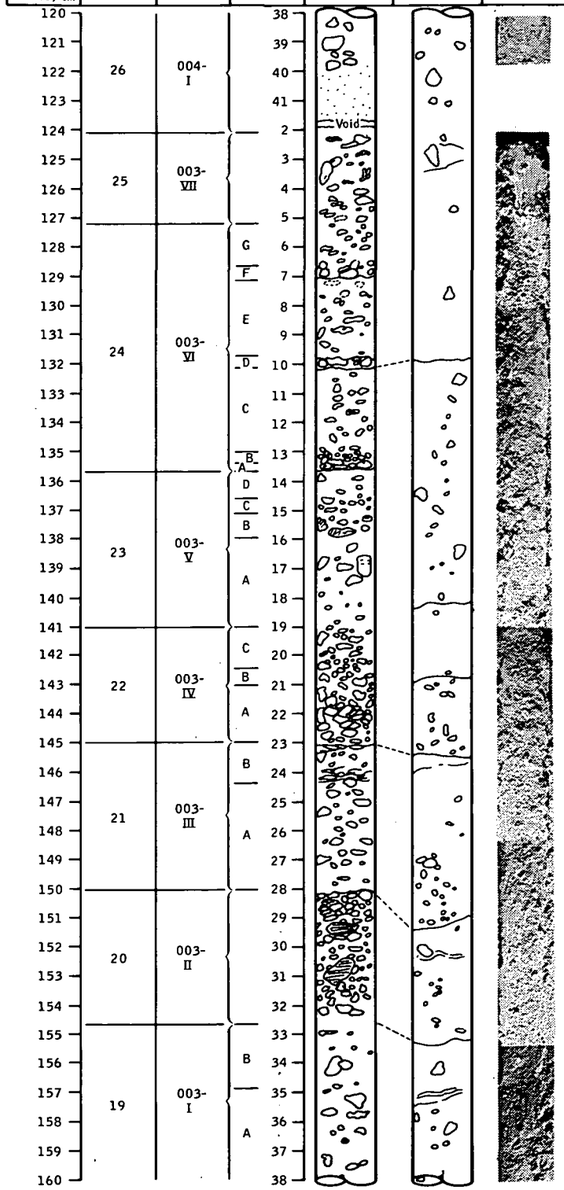
								**Color	Texture	Structure	Composition of larger rock fragments	Subunits
80–81	31	005-II	40–41					10 YR 5/2 greyish brown	Coarse sandy soil.	Uniform, unbroken layer.	Abundant brown glass droplets and agglutinates.	None
81–83	30	005-I	41–43					10 YR 6/1 grey	Granule and coarse sand bearing silt size soil.	Cohesive; forming small clumps up to 5 mm long.	(1) abundant microbreccia fragments	None
83–95	29	004-IV	43–13					10 YR 5/1 to 10 YR 5/1 grey	Poorly sorted granule-bearing silt-size soil. Coarser fragments vary from 10% near the top to 0 near the base of the bed; it is reversely graded.	Moderate slumping; forming 4-5-mm long clumps.	1. Light grey to dark grey breccias; some with dark brown glass coatings. 2. Clastic rocks consisting of green glass spheres and isolated spheres. 3. Trace of small, powdery white "anorthositic" fragments.	None
95–101	28	004-III	13–19					10 YR 5/2 greyish brown (patches of lighter grey soil)	0-5% granule to coarse sand-size particles in silt-size soil.	Moderate slumping; forming 4-5-mm long clumps.	1. White, powdery "anorthosite" fragments. 2. Light grey breccia fragments; a few have dark grey-brown glass coatings. 3. White aggregates of "clods".	None
101–108	27	004-II	19–26					10 YR 5/1 grey	Coarse sand to granule-bearing fine sand-size soil. Possible reversely graded.	Forms very fragile blocks, 2 x 4 to 10 mm long; slumps easily.	1. Light to dark grey breccia fragments. 2. Grey and black angular glass fragments. 3. Trace of green glass.	None
108–120	26	004-I	26–38					10 YR 5/1 grey	Moderately well-sorted silt-size material. 1-3% of the volume is composed of fragments greater than 1 mm long.	Forms coherent blocks 2-5 mm long. There was little collapse when the core was opened.	1. Light grey breccia fragments. 2. Trace of dark brown and grey glass fragments.	None

*The individual sample locations are based on this scale.
**Munsell Color Co., Inc., Munsell Soil Color Charts, 1954 ed., Baltimore, Md.

TABLE II. - DESCRIPTION OF THE APOLLO 15 DRILL CORE - Continued



Lithologic Description					
**Color	Texture	Structure	Composition of larger rock fragments: Coarse fraction	Fines	Subunits
See previous page for lithologic description of 004-I.					
5 Y 3/1 dark drab grey	Clayey siltsoil 15-20% vf-f sand 2.94% avg rock fragments. Matrix support.	Only zone with slight collapse when core was opened, forms coherent blocks up to 1.3 cm long, mostly about 0.3 cm.	Soil matrix breccia with glass aggregates and whitish granules 50.0% Lumpy and frothy, very dark brown to black glass aggregates 23.7% Non-crystalline lithic fragments, soil-like appearance, but with no clasts or inclusions 7.8% Microcrystalline dark grey rock fragments, (basalt?) 7.8% White-matrix breccia, sugary texture 5.2% Anorthositic rock fragments, chalky appearance 5.2%	20-25% feldspar cleavage frag 1-2% whitish granules	
5 Y 3/1 to 5 Y 4/1 medium to dark drab grey	Clayey fine sandsoil, 20-60% sand, up to 22% rock fragments, avg 5.5% framework support in some zones.	Variable slumping, some portions collapse readily, others moderately breaks into blocks or pellet like clumps up to 4 mm diameter, mostly 1 mm.	A, B, C / D, E / F, G Soil-matrix breccia 40.3 / 51.5 / 64.0% Dark, frothy spattered glass 1.7 / 12.5 / 8.0% Aphanoxtalline dark blocky lithic fragments 7.0 / 2.5 / 8.0% Anorthositic rock fragments, chalky 15.8 / 2.5 / 8.0% Sintered-appearing brownish breccia 12.3 / 2.5 / 8.0% Non-xtalline, dull granular lithic fragments 15.8 Coarsely xtalline anothosite 7.0 / 5.0 / 4.0% Dark crystalline (gabbro?) fragments 7.5 Glass sphere (dark greenish brown) 2.5 White-matrix breccia, sugary texture 7.5	35-50% feldspar cleavage frag 1-2% whitish granules	G. Matrix-rich layer. F. Rock layer, white granules. E. Matrix-rich layer. D. Rock layer, sugary breccia. C. Matrix-rich layer. B. Layer of 1-2 mm rock fragments. A. Layer of 2-6 mm breccia fragments.
10 Y 4/1 to 5/1 medium neutral drab grey	Muddy siltsoil, 20-25% vf sand, 3.14% rock fragments, matrix support, poorly sorted.	Slumps easily into blocky and crumb-like clumps 0.2-4 mm long, average diameter 1.5-2 mm.	Soil-matrix breccia fragments with glass aggregates and fragments 60.3% Non-crystalline, soil colored, rounded lithic fragments 13.8% Anorthositic rock fragments with chalky appearance 10.3% Sintered-appearing, brownish breccia fragments 5.2% Aphanocrystalline dark grey, blocky lithic fragments (basalt?) 5.2% Splintery drab lithic fragments, indet composition 3.4% Frothy, dark brown to blackish glass aggregates 1.7%	35-50% feldspar cleavage frag 1-2% whitish granules	D. Basic composition of unit. C. Concentration of anorthositic granule. B. Concentration of frothy glass. A. Basic composition of unit.
5 GY 5/1 to N5 neutral to drab grey	Muddy sandsoil, 25% vf-med sand, 10.36% avg rock fragments very poorly sorted. Some framework support.	Moderate slumping forms crumb-like clumps 0.1-2.5 mm long, variable sizes averaging 1 mm.	White-matrix breccia, sugary texture, dark grey to brown clasts 22.8% Soil-matrix breccia with glass aggregates and fragments 21.5% Irregularly angular, dark grey microcrystalline (basalt?) fragments 15.2% Non-crystalline grey lithic fragments, soil-like appearance, rounded 13.9% Sintered-appearing, tan to brownish breccia fragments 10.1% Frothy to finely divided, dark-brown to black glass 3.8% Non-crystalline, dark grey, indet lumpy lithic fragments 3.8% Anorthositic rock fragments, chalky appearance 3.8% Feldspar cleavage fragments, medium bluish grey 2.5% Blackish glass bead 1.3% Cindery-appearing, dark grey glass fragments 1.3%	25-35% feldspar cleavage frag 1-2% whitish granules	C. Basic composition of unit. B. Concentration of rounded soil matrix breccia fragments A. Basic composition of unit.
5 GY 5/1 medium neutral drab grey	Clayey siltsoil, 20-25% sand, 7.01% avg rock fragments. Matrix support.	Moderately slumping, forms crumb-like clumps 0.1-1 mm long, mostly 0.5-1 mm.	Soil-matrix breccia with glass fragments and aggregates 36.4% Irregularly jagged, very dark grey lithic fragments (basalt?) 20.4% Sintered-appearing tan-brownish crystalline breccia 11.4% Non-crystalline lithic fragments, soil-like appearance 11.4% Vesicular to frothy, dark greenish brown to black glass 9.1% Anorthositic rock fragments with chalky appearance 6.8% Indet. splintery grey crystalline lithic fragments 4.5%	25-35% feldspar cleavage frag Tr-1% whitish granules	B. Permeated by cracks. A. Resistant bed.
5 Y 5/1 medium neutral drab grey	Rock fragmental sandsoil. Moderate to well sorted, 21.93% rock fragments. Grain support.	Slumps easily, forms crumb-like clumps 0.5 to 3 mm long, mostly in 1 mm range.	Soil-matrix breccia with glass fragments and aggregates 21.6% Anorthositic rock fragments with chalky appearance 17.0% Irregularly jagged, very dark grey lithic fragments (basalt?) 17.0% Frothy to finely divided, dark greenish to black glass aggregates 14.8% Sintered-appearing, brownish to tan, crystalline breccia 9.1% Dark grey, metallic-appearing, angular crystalline fragments 8.0% Non-crystalline lithic fragments, soil-like appearance 4.5% Cindery glass fragments, dull grey 2.3% Sugary-textured, white matrix breccia, dark grey clasts 2.3% Indet splintery, drab grey lithic fragments 2.3% Feldspar cleavage fragments 1.1%	10-15% feldspar cleavage frag Tr whitish granules	
10 YR 5/1 medium neutral to brownish grey	Clayey siltsoil. Moderately to poorly sorted, 4.55% avg rock fragments.	Slumps readily, collapsing into blocky or pellet-like aggregates 0.5 to 3 mm long.	Irregularly jagged, very dark grey lithic fragments (basalt?) 44.3% Frothy to finely divided pale brown or dark glass aggregates 16.5% Soil-matrix breccia or lithified soil-matrix fragments 15.2% Anorthositic rock fragments, chalky appearance, angular 11.4% Dark grey, metallic-appearing, angular crystalline fragments 2.5% Indet splintery, drab grey lithic fragments 2.5% Sintered-appearing brownish crystalline breccia fragment 1.3%	2-5% feldspar cleavage frag 0-Tr whitish granules	B. Relatively less slumping forms pellet-like clumps, Tr anorthositic nodules. A. Collapses easily.

*The individual sample locations are based on this scale.
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TABLE II. - DESCRIPTION OF THE APOLLO 15 DRILL CORE - Continued

Scale; apparent distance below lunar surface, cm	Permanent unit designations	Temporary unit designations	*Scale; from the top of each metal stem, cm	Sketch of core	Sketch of x-radiograph	Photograph of core	Photograph of a peel from the core	Lithologic Description			
								**Color	Texture	Structure	Composition of larger rock fragments	Subunits
160–167	19	003-I	38–43					Between grey and dark grey	Coarse sand and granule bearing silt size; very poorly sorted.	No cohesive aggregates.	1. Black glass 2. White "anorthosite"	None
		002-XI	3–4	Void								
167–176	18	002-X	4–9					Darker grey than IX; lighter grey than XI	Granule-bearing silt size; poorly sorted.	Cohesive aggregates present: 1. Equant, same color as soil. 2. Equant, 1 mm diameter light grey.	N.D. (dusty).	None
	17	002-IX	9–13					Grey	Pebbly medium sand size; very poorly sorted.	No cohesive aggregates.	1. Medium grey breccia. 2. White "anorthosite".	None
176–183	16	002-VIII	13–20					Grey to light grey	Silt to fine sand size; moderately sorted.	Some 1 mm diameter cohesive aggregates.	1. Dark grey breccia. 2. Light grey glass fragments. 3. "Anorthosite".	B. Grey soil forms irregular clumps. A. Light grey; more porous than B
183–184	15	002-VII	20–21					Grey	Pebbly fine sand size; poorly sorted.	No cohesive aggregates.	1. Grey glass. 2. Grey breccia.	None
184–189	14	002-VI	21–26					Light grey; grading to darker grey at top	Granule-bearing silt size; poorly sorted.	There are small granule size, light to medium grey cohesive aggregates.	1. Dark grey breccia. 2. Light grey breccia. 3. "Anorthosite".	None
189–191	13	002-V	26–28					Grey (5 Y 5/1) to light grey	Coarse-sand bearing silt size; poorly sorted.	No cohesive aggregates.	1. White "anorthosite".	C. Light grey. B. Two distinct. A. Light grey color bands.
191–200	12	002-IV	28–36					Grey (5 Y 5/1) to dark grey (5 Y 4/1)	Silt-size soil to coarse-sand and granule-bearing silt-size soil; moderately sorted.	Light grey to white cohesive aggregates (<4 mm diameter).	1. White "anorthosite". 2. Grey breccia. 3. Trace of black glass.	F. Grey, coherent. E. Light grey, with darker grey patches. D. Grey, smooth surface; coarser. C. Light grey, coherent; grades into B. B. Dark grey; smooth surface A. Light grey; smooth surface.
200	11	002-III	37									

See next page for a description of this unit.

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Scale; apparent distance below lunar surface, cm	Permanent unit designations	Temporary unit designations	*Scale; from the top of each metal stem, cm	Sketch of core	Sketch of x-radiograph	Photograph of core	Photograph of a peel from the core	Lithologic Description				
								**Color	Texture	Structure	Composition of larger rock fragments	Subunits
200	11	002-III	37					Grey (5 Y 5/1)	Silt size; moderately well sorted.	No cohesive aggregates.	None	None
201	10	002-II	38					Grey (5 Y 5/1)	Coarse sand and granule-bearing silt-size soil.	No cohesive aggregates.	Too dusty for identification.	None
202			39									
203		002-	40									
204		I	41	D				Grey (5 Y 5/1)	Granule-bearing fine silt-size soil.	Some white cohesive aggregates. Prismatic fracture pattern.	1. White "anorthosite" 2. Feldspar crystals.	B. Abundant black glass droplets. A. Some anorthositic fragments; about 20% fragments > 1 mm.
205	9		42									
206			1	Void								
207		001-	2	B								
208		IX	3	A								
209	8	001- VIII	4					10 YR 7/1 light grey	Silt-size soil; moderately well sorted.	No cohesive aggregates.	1. Light grey to white breccia fragments. 2. Some black glass fragments.	None
210			5									
211	7	001- VII	6					10 YR 7/1 light grey	Granule-bearing silt-size soil.	≈ 2% cohesive, grey aggregates.	1. Vesicular black glass fragments. 2. Light grey breccias.	None
212	6	001- VI	7					10 YR 7/1 light grey	Silt-size soil.	Some brown and white cohesive aggregates.	1. Light grey breccia fragments. 2. Black glass fragments and droplets.	None
213			8									
214	5	001- V	9	C B				10 YR 7/1 light grey	Pebbly silt-size soil.	Abundant white and grey cohesive aggregates.	1. Grey breccia fragments. 2. Black glass fragments. 3. Basalt(?) fragments.	C. 20-30% granule-size fragments; abundant black glass. B. > 20% granule-size fragments; abundant clods. A. ≈ 5% granule-size fragments; abundant clods.
215			10	A								
216	4	001- IV	11	B				10 YR 8/1 white	Silty fine sand-size soil.	Distinct fine (0.5 mm) laminae. Less coherent than Unit V.	1. Abundant black glass droplets and fragments. 2. Grey breccia fragments.	B. Slightly coarser and more black glass than Unit A. A. Abundant coherent aggregates (clods).
217			12	A								
218			13	J								
219			14	I				10 YR 7/1 to 10 YR 8/1 light grey to white (Subunits A-D are white)	Granule-bearing silt-size to sandy silt-size soil.	Weak angular blocky structures, 2-3 mm long. Very few weakly consolidated clods.	1. Light grey to white breccia fragments. 2. Basalt(?) fragments. 3. Most fragments coated with dust; are nearly impossible to identify. 4. Trace of black glass fragments and droplets.	J. 10-20% fragments > 1 mm; basalt fragments. I. Silt-size material with trace of granules. H. Silt-size soil. G. 5-15% fragments (Basaltic?) in a silt matrix. F. Trace of clods in a silty matrix. E. 10% fragments of basalt (?) > 1 mm in a silty matrix. D. Lighter grey than E; coarser grained matrix than C. C. Some weakly consolidated clods. B. Silty fine sand-size matrix, with ≈ 20% fragments > 1 mm. A. Silty fine sand-size matrix, with ≈ 30% fragments > 1 mm.
220			15	H								
221			16	G								
222	3	001- III	17	F								
223			18	E								
224			19	D								
225			20	C								
226			21	B								
227			22	A								
228			23									
229			24	F				10 YR 7/1 light grey	Granule-bearing sandy silt-size soil.	Angular, 1-2 mm blocky structures, with thin, long prisms along the interior of the drill stem.	1. Light grey breccia fragments. 2. Medium grey, aphanitic basalt fragments. 3. Trace of black glass.	F. Possible graded bed, with 10-40% fragments > 1 mm. E. Less basalt(?) fragments than Unit E. D. Silt-size sand. C. 25% fragments > 1 mm. B. Silt-size soil. A. 12-50% fragments (light-grey breccias) > 1 mm.
230			25									
231			26	E								
232	2	001- II	27	D								
233			28	C								
234			29	B								
235			30	A								
236			31	F				10 YR 7/1 light grey	Silt-size soil.	A few clods present.	1. Light grey breccia fragments. 2. Vesicular grey basalt. 3. Dark brown glass.	F. Silt-size soil. E. 10-20% particles > 1 mm, in a silty matrix. D. Silt-size soil. C. Some aggregates (clods) present. B. Silt-size soil. A. Silt size, with some > 1 mm diameter clods.
237			32	E								
238	1	001- I	33	D								
239			34	C								
240			35	B								

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								**Color	Texture	Structure	Composition of larger rock fragments	Subunits
240 241 242 243 244 245 246 247 248	1	001- I	B 35 A 36	Void	Void			See previous page for description.				

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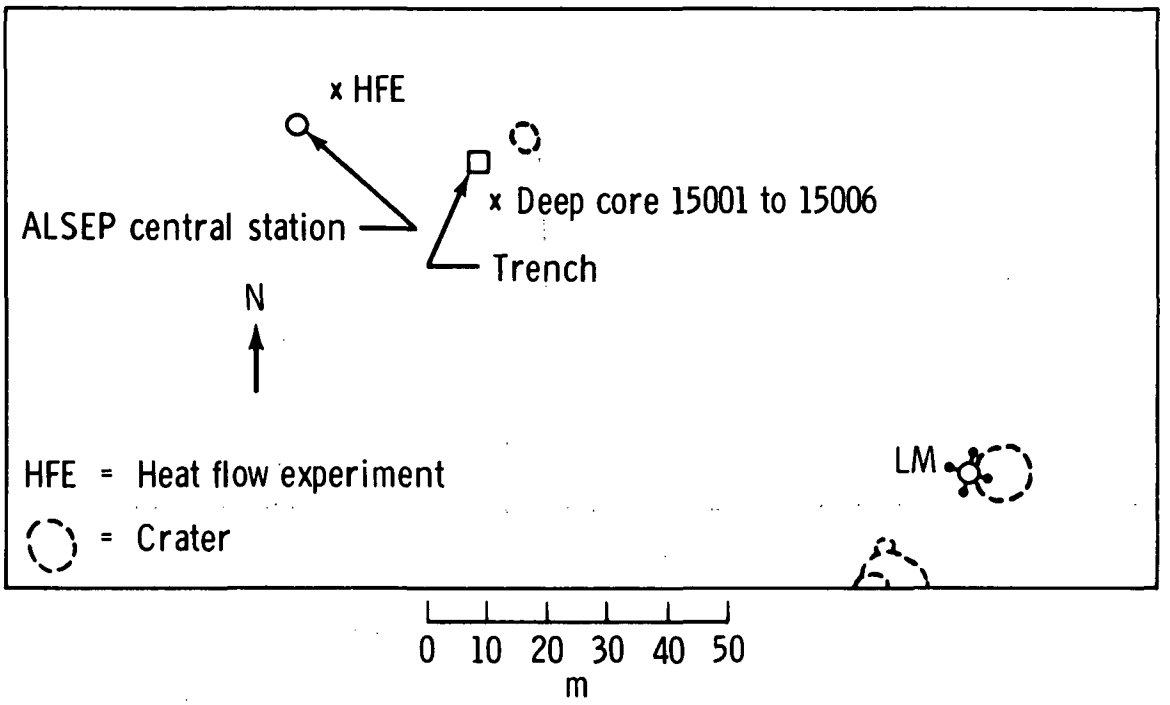

Figure 1.- Sketch map of the ALSEP-lunar module site area.